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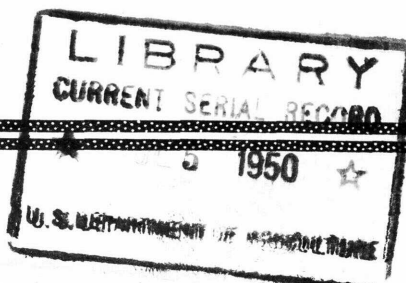
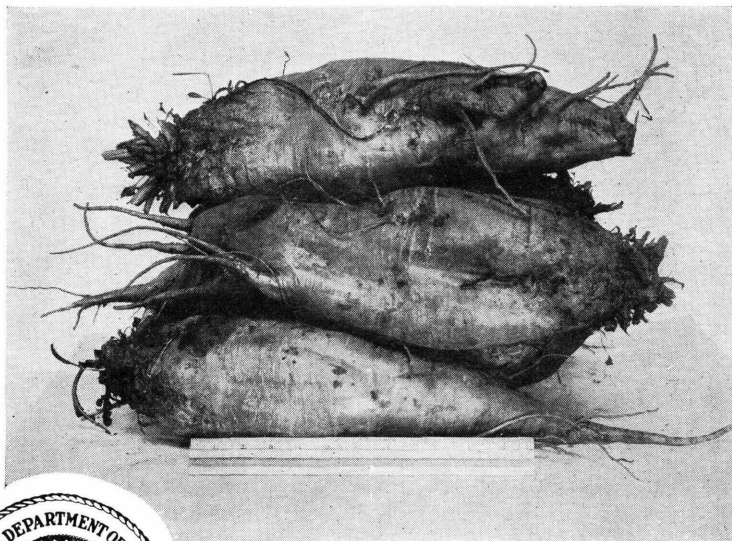
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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1699

GROWING ROOT CROPS FOR LIVESTOCK



ROOT CROPS most generally grown for feeding livestock include mangels, rutabagas, turnips, and carrots. They have not been extensively grown in the United States for this purpose chiefly because of the large amount of hand labor involved, and because succulent feed can be produced more cheaply as corn silage.

Root crops require a cool, moist climate for their best development, and under such conditions they may sometimes be grown to better advantage than corn. A well-prepared seed bed and an abundance of available plant food are essential to large yields. The time, rate, and method of seeding varies with the crop and with local conditions. Thorough cultivation and thinning are essential to normal root development and involve considerable hand labor.

Roots should be harvested before severe frost and stored in cellars or pits.

Mangels, rutabagas, turnips, and carrots do not differ greatly in composition, all having more water and less protein, fat, and carbohydrates than corn silage. They are chiefly valuable as a source of succulence and as appetizers and are highly prized by breeders and exhibitors of purebred stock. Roots are sometimes fed whole, but when large they should generally be cut. They are especially valuable for cows being milked. Ordinarily the limit in feeding is 3 to 5 pounds per 100 pounds of live weight, and the usual amount fed is generally not more than one-half this quantity. Excessive feeding may cause indigestion.

Under favorable conditions mangels, rutabagas, and turnips yield 20 to 30 tons per acre. The usual tonnage obtained from carrots under similar conditions is about one-half this amount.

GROWING ROOT CROPS FOR LIVESTOCK

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ROOT CROPS as feed for livestock and poultry have attracted relatively little attention in the United States. One of the principal reasons for this is the amount of hand labor required in producing such a crop. In the greater part of the United States corn will produce a larger tonnage of succulence in the form of silage than can be obtained from root crops, and the silage usually can be produced much more cheaply, since it requires comparatively little hand labor. In certain sections, however, where soil and climatic conditions are especially favorable to root crops, a much greater tonnage can be obtained from them than from corn. Under such conditions root crops are worthy of consideration as sources of succulence, especially during the winter months, when little or no green feed is available. Furthermore, for the farmer who does not keep enough livestock to justify the use of a silo, root crops may advantageously supply the succulence needed for winter feeding.

The discussion of root crops in this bulletin is confined to mangels (mangel-wurzel, mangolds or stock beets, a large-growing type of beet of the species *Beta vulgaris* L.), rutabagas or swedes (*Brassica campestris* L.), turnips (*B. rapa* L.), and carrots (*Daucus carota* L.); crops that are most generally grown for the specific purpose of feeding livestock, although under certain conditions other root crops are utilized rather extensively for the same purpose.

SOIL AND CLIMATIC RELATIONS

A cool, moist climate is the most favorable for root crops, although some remarkably satisfactory yields have been obtained under dry-farming conditions in the northern Great Plains where proper attention has been given to soil preparation and plant spac-

ing so that the competition for moisture is not too great. (Fig. 1.) In general, a deep, fertile loam is best, although fairly good crops have been produced on soils ranging in texture from a sandy loam to clay. A soil good for corn is generally satisfactory for root crops. Nearly ideal soil conditions are found on some of the diked lands and beaver-dam lands of the Pacific Northwest. These soils are usually well supplied with organic matter, are friable, and generally productive. These characteristics, together with the cool summer weather, present excellent conditions for root-crop production, and as a result some remarkable yields have been obtained. The soil



FIGURE 1.—Field of beets in Oregon. Red beets and carrots after market goes off for table stock, as well as stock beets and mangels, are used for feed.

and climatic conditions in parts of Minnesota, Michigan, Wisconsin, New York, and the New England States are also particularly well suited to root crops.

VARIETIES

There are many varieties of mangels, rutabagas, turnips, and carrots, the four classes of roots most commonly grown for feeding livestock.

The Mammoth Long Red variety is probably the most popular mangel and has generally given the highest yields, especially on deep soils. The illustration on the cover page shows this variety grown at Redfield, S. Dak., in 1920, a favorable season. For shallow soils some of the shorter-rooted varieties are preferable. Other common varieties include Giant Half Sugar, Red Intermediate, Golden Tankard, Danish Sludstrup, Giant Red Eckendorf, and Heavy Cropper, the last mentioned being grown under various local names of which Giant Gatepost is most common. The most popular varieties of rutabagas are the American Purple Top, Improved Purple Top, White Sweet Russian, Carter hardy swede, Bangholm,

and Hurst Monarch. Among the common varieties of turnip are Purple Top White Globe, and Cowhorn. Other varieties popular in the Pacific Northwest are Hardy Green Round, White Pomeranian, White Top Aberdeen, and Green Top Aberdeen. Bortfield and Centenary, newest varieties for this region, are good producers' sorts and are fairly resistant to attacks of root maggots and aphids, insects that sometimes cause considerable damage to turnips and rutabagas. The most popular varieties of carrots include White Belgian, the standard white short, and the yellow-fleshed varieties, Improved Long Orange, Mastodon, Ox-heart, Chantenay, Danvers, and Giant Yellow.

The White Belgian is sometimes objected to in the Pacific Northwest because of its tendency to root so deeply on loose soils that it is harvested with difficulty. In this region the half-long types are preferred where the crop is to be harvested and stored, but where hogs or sheep are to harvest the roots, the Ox-heart variety is most popular as it is easy to remove from the soil.

GROWING THE CROP

PREPARING THE SEED BED

Soil preparation varies with local conditions. In most cases, plowing the land in the fall gives a seed bed more favorable to root crops. The following spring, as soon as the soil is sufficiently dry, it should be disked thoroughly and harrowed to insure a firm, fine, weed-free seed bed 5 to 6 inches deep. If the soil is heavy it may be necessary to plow the land again in the spring. Such soils should not be too finely pulverized, as they are likely to crust after rains. If the preparation is delayed until spring, the land should be plowed as early as possible and thoroughly disked and harrowed to encourage the germination of the weeds, which may then be destroyed before the root crop is sown. Sandy soils may require compacting with a cultipacker or ordinary roller.

FERTILIZING AND LIMING

An abundance of available plant food is essential to large yields. Some of the relatively new lands in the northern Great Plains, especially where dry farming is practiced, seem to have sufficient available plant food for root crops, but in most other parts of the United States increased yields amply justify liberal fertilizing. Experience has shown that in most cases nothing is superior to good barnyard manure applied at the rate of 10 to 20 tons per acre, either to a preceding crop or else turned under in the fall. Fine, well-rotted manure may be applied early in the spring and mixed with the soil by disking; but coarse strawy manure applied at this time causes excessive drying out of the soil and may interfere with the cultivation of the young seedlings.

Where manure is not available a 4-16-4 or a 4-16-8 commercial fertilizer should be applied at the rate of 400 to 700 pounds per acre just before seeding. In the Pacific Northwest superphosphate alone applied at the rate of 350 to 400 pounds per acre has given excellent results. Some growers in this region use well-rotted barnyard manure at the rate of 20 tons per acre, supplementing it with

300 to 400 pounds of superphosphate. On many soils one or two applications of commercial fertilizer after the roots are started will be justified by the increased yields.

Acid soils should be limed before sowing root crops, the amount required varying, of course, with the soil and previous treatment. Soils of average acidity will require about 2 tons of ground limestone or its equivalent in some other form applied to some preceding crop. Land on which alfalfa has been grown successfully will not require additional applications of lime for root crops.

TIME OF SEEDING

Mangels and carrots require a full growing season and should be sown as soon as danger of frost is past. This time will of course differ in different parts of the United States but will usually be a little earlier than corn-planting time. In the extreme North the earliest date at which root crops may be safely sown will be about May 1; southward the date will be progressively earlier. Rutabagas and turnips do not require so long a growing season as mangels and carrots and being less sensitive to cold will continue to grow later in the fall.

The time of sowing rutabagas and turnips will depend on the time at which they are desired for feeding. If early fall feed is wanted, the seed should be sown early, and if the roots are wanted for late feeding or storage for winter feed, they may be sown as late as June 15 in the Northern States and as late as July or August farther south. In some sections early seedlings are injured by root maggots and aphids, but such damage is seldom serious where seeding is delayed until June 15 or later.

In the extreme South and along the Pacific coast of Oregon and Washington rutabagas and turnips are sometimes sown in the fall and continue their growth more or less throughout the winter. Carrots are usually sown after the soil becomes sufficiently warm to insure rapid germination. Under dry-farming conditions early spring seeding of all root crops is essential, since the summer moisture is generally deficient and yields are likely to be unsatisfactory unless the plants are started early enough to get the full benefit of the spring moisture.

RATE OF SEEDING

The rate of seeding depends on whether the seed is sown broadcast or in rows, and on the distance between rows. When sown in drills 30 to 36 inches apart the seeding rates recommended for the various root crops are approximately as follows: Mangels, 6 to 8 pounds; carrots 1½ to 2 pounds; rutabagas and turnips, 1 pound per acre; when sown broadcast, the rate of seeding turnips should be 4 to 5 pounds per acre. As the seed of mangels quite often does not germinate readily and as the seedlings sometimes have difficulty in pushing through the soil, a liberal seeding rate usually pays.

METHOD OF SEEDING

The best yields are secured when root crops are sown in cultivated rows. Where the acreage is large, the rows should be at least

24 to 36 inches apart to permit efficient use of cultivators. Where the ordinary corn cultivator is to be used, the rows should be 36 to 42 inches apart. In the case of small acreages that are to be cultivated with a hand cultivator, the rows may be 18 to 24 inches apart. Where the moisture supply is limited, as in the northern Great Plains, a better root development results if the rows are 36 to 42 inches apart. Carrots do not require as much space between the rows as do mangels. When sown in the fall or on stump land that is difficult to cultivate, the seed of turnips and rutabagas is usually broadcast.

In some cases turnips and rutabagas are sown broadcast at the last cultivation of another crop such as corn or potatoes, but the yields are considerably less than when they are sown alone. Occasionally turnips are sown with oats, and after the oats have been harvested the turnips furnish considerable feed if moisture conditions are favorable.

Small acreages may be sown with a hand seeder or small drill. On well-prepared land one person can sow 2 or 3 acres a day with a hand seeder, the rows being 30 inches apart. In sowing larger acreages the small types of grain drills are satisfactory if the flow of the seed is properly regulated. Whatever method is used the seed should be uniformly distributed and dropped in contact with moist soil but not covered too deeply. In sandy loams mangels should be covered three-fourths inch and in clay soils one-half inch. On similar soils carrots should be covered one-fourth to one-half inch.

CULTIVATION

Frequent and thorough cultivation to check weed growth and to maintain a loose-surface mulch are essential to success in growing root crops. The first cultivation should be given as soon as the rows can be seen. The first two cultivations should be deep and close to the row. Subsequent cultivations should be quite shallow and at intervals of two weeks until the plants are so large that cultivation without injury is no longer possible. Usually the last cultivation will be given between August 1 and 15. The hand cultivator may be used for small acreages, but for larger fields the power-drawn cultivators, such as the ordinary corn cultivator, is used.

Where there is a thick stand it is sometimes helpful to go across the rows with a weeder soon after the plants emerge. This usually does not injure the crop to any extent but does assist materially in destroying young weeds and in breaking the surface crust. Hand weeding is usually necessary to keep the weeds out of the rows. It is evidently impractical to use tillage implements on broadcast sowings, but hand weeding is sometimes practiced.

THINNING

Proper thinning is essential to the development of normal roots and to securing satisfactory yields. When the plants have developed three or four leaves they should be blocked out with a sharp hoe, after which the thinning to single plants should be completed by hand. The most desirable distance between individual plants will vary with the soil, rainfall, and distance between rows. With opti-

mum moisture conditions, the most desirable spacing for the various crops when grown in 30-inch rows is as follows: Mangels, 12 inches; rutabagas, 10 to 12 inches; turnips, 10 inches; carrots, 6 to 8 inches. Along the Pacific coast, carrots are seldom thinned and only about half the acreage of turnips and rutabagas is thinned.

HARVESTING

The general practice is to harvest root crops before a severe frost or when growth ceases, as indicated by the yellowing and withering of the leaves. Mangels and carrots will not stand as much cold as rutabagas and turnips and must therefore be harvested somewhat earlier. To make harvesting easier a common plow is often used to throw the soil away from one side of the row, after which the roots are easily lifted. If the acreage is considerable, the beet lifter is sometimes used to loosen the roots.

The roots are either topped as they are pulled or thrown into piles and topped later; the tops are sometimes twisted off and sometimes cut off with a sharp knife. A few growers cut the tops with a sharp hoe before the roots are lifted. After topping, two or more rows are usually thrown into a windrow and later hauled to the place of storage. Where possible the roots should be harvested on a cool, bright day when the soil is dry so that most of it will shake off before the roots are stored. As mangels and carrots bruise more easily than rutabagas and turnips, they should be handled more carefully, because badly bruised roots do not keep well in storage.

In the Pacific Northwest, turnips do not keep well in storage and are harvested as needed for feeding. Hogs and sheep are sometimes turned into the field to harvest carrots and small turnips.

STORING

Roots should be stored where they will be easily accessible during the winter, preferably on same floor of the barn where they are to be fed. Root cellars built in an excavation are less expensive than storage houses, as they do not require so much protection against freezing. The walls of an excavated cellar may be constructed of concrete at a comparatively low cost. The temperature of the cellar should never reach the freezing point and should be kept at 36° to 40° F. The ceiling and walls should be sufficiently insulated to prevent fluctuation in temperatures. Ventilating flues and slatted floors underneath the roots are necessary to provide for the escape of moist heated air and to admit fresh air. In dry climates roots to which some soil has adhered in harvesting may keep better in storage.

Although generally less satisfactory, the use of pits may be resorted to when necessary. However, extremely cold spells may interfere with feeding roots from pits. A high, well drained place should be selected for the pit. The pit should be 8 or 10 inches deep, and may be circular or long and narrow. In a circular pit the roots should be placed in a cone-shaped pile; in a long, narrow pit they should be in a long pile about 3½ feet high and 4 feet wide at the bottom. The sides of the pile should slope sufficiently to cause water to drain off rapidly from the covering. Ordinarily

the piles should be covered with 3 to 6 inches of straw and then with an equal thickness of soil. The thickness of the covering, which should be sufficient to prevent freezing, will differ with climatic conditions. If the roots are to be kept well into the winter, it may be necessary to add another layer of straw and another of soil. A ventilating flue, large enough to permit the escape of damp air and to insure good air circulation, should be provided.

COMPOSITION

The average composition of the various root crops is given in Table 1. For the sake of comparison the average of several analyses of corn silage have been included in the table. It will be noted that the average composition of the various kinds of roots is very similar. Analysis of individual roots of mangels have shown a dry-matter content ranging from 7 to 14 per cent, there usually being as great difference between individuals of a variety as between varieties.

TABLE 1.—Average composition and digestible nutrients of several root crops, corn silage, corn, and barley¹

Feed	Moisture	Ash	Crude protein	Carbohydrates		Fat, or ether extract	Digestible protein	Digestible carbohydrate equivalent
				Crude fiber	Nitrogen-free extract			
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Artichokes.....	78.0	1.8	2.4	0.9	16.8	0.1	1.5	16.1
Carrots.....	88.6	1.0	1.1	1.3	7.6	.4	.9	8.9
Mangels.....	91.2	1.0	1.4	.8	5.4	.2	1.1	6.4
Potatoes.....	78.9	1.0	2.1	.6	16.3	.1	1.3	16.3
Red beets.....	88.5	1.0	1.5	.9	8.0	.1	.9	8.7
Rutabagas.....	88.6	1.2	1.2	1.3	7.5	.2	1.0	8.5
Sugar beets.....	78.0	1.0	1.5	2.9	16.5	.1	.9	19.2
Sweet potatoes.....	71.1	1.0	1.5	1.3	24.7	.4	.9	24.2
Turnips.....	90.6	.8	1.3	1.2	5.9	.2	1.2	7.4
Corn silage.....	70.9	1.4	2.4	6.9	17.5	.9	1.4	18.9
Barley.....	9.6	2.9	12.8	5.5	66.9	2.3	10.4	63.8
Corn.....	12.9	1.3	9.3	1.9	70.3	4.3	7.1	74.8

¹ The analyses and digestible nutrients of the feeds listed above have been compiled by the Miscellaneous Division, Bureau of Chemistry and Soils, and the Animal Husbandry Division, Bureau of Animal Industry, U. S. Department of Agriculture. The carbohydrate equivalent shown in the last column of the table is the sum of the digestible crude fiber and nitrogen-free extract plus 2.25 times the digestible fat.

FEEDING

In general, wherever starchy concentrates, such as corn and barley, can readily be produced at a lower cost per unit of dry matter than root crops, the value of root crops in livestock feeding is limited to the feeding of small quantities, such as 1 to 2 pounds per 100 pounds live weight daily, as a source of succulence and as an appetizer in the ration. Throughout most of the United States, corn, sorgo, and grain-sorghum silages are cheaper sources of succulence than root crops when the number of livestock is sufficient to consume 50 tons or more of silage during a period of three or four months. These limitations vary considerably with the kind of silage, type of silo, and weather conditions.

Root crops are prized by breeders of purebred stock and especially by exhibitors, as they are excellent conditioners and the roots can be stored and transported under conditions impossible with silage.

Roots should be classed as highly diluted concentrates rather than as roughages. On account of their high water content, excessive feeding may overload the digestive organs and cause indigestion. Ordinarily the limit is 3 to 5 pounds per 100 pounds live weight and not over half that amount when the roots are to be fed as a source of succulence and as an appetizer and not as an important source of nutrients.

As a class roots are deficient in protein, fat, calcium, and phosphorus, and with the exception of carrots are relatively deficient in vitamin A. As a whole, roots are a fair source of vitamins, but they do not occupy the same place in animal feeding with regard to vitamin A, calcium, and iron as do the leafy, green, or yellow feeds. Carbohydrates mainly in the form of sugar are the principal nutrient, and the sugar content rises considerably during storage, as some of the starch is converted. Much of the crude fiber is in the outer skin. Being a carbonaceous feed, roots should be fed with a liberal allowance of legume hay for maintenance and a liberal allowance of grain and legume hay or grain, oil-mill by-products, and nonlegume hay for fattening. As the dry matter of roots is practically equal in nutritive value to the dry matter of grain, it takes approximately 8 to 10 pounds of roots to equal 1 pound of grain.

Experiments at the Colorado station indicate that the dry matter of roots is about one-third more valuable when fed with grains in about equal parts of dry matter than when fed without such a complement of concentrates. In fattening rations not over half of the dry matter in the concentrate should be from roots, the balance being from grain and from cereal and oil-mill by-products.

In large quantities it takes from 1½ to 2 pounds of roots to equal a pound of corn silage, on account of their higher water content; but when fed in small quantities as an appetizer a pound of roots is usually equal to a pound of silage.

When first harvested root crops have a laxative effect, which disappears to a large extent after they have been stored for a few weeks. For this reason it is advisable to delay feeding mangels until after Christmas.

PREPARATION OF ROOTS FOR FEEDING

Roots may be fed in various ways—in the field where grown, whole after storage, or cut into strips, chips, or squares by chopping boxes built for the purpose. When the roots are large, hard, and woody, old animals with poor teeth or young animals are unable to eat them satisfactorily until they have been cut. Dirt should be removed before putting them into the cutter, unless the cutter has provision for cleaning the roots before they reach the knives. Meal and chaffy roughage may be mixed with chopped roots to improve the palatability of the ration and reduce the waste.

Cooking or steaming is wasted labor and expense, because the nutritive value of the roots is decreased rather than increased by the destruction of some of the vitamins.

For poultry all roots should be fed whole, as chickens enjoy picking them.

ROOT CROPS FOR CATTLE

While it is rarely profitable in the United States to raise root crops for maintaining or fattening cattle, turnips and carrots that are too small or too inferior in quality to use or market as food can be fed to good advantage.

Where roots are as cheap a source of dry matter as grain, from 30 to 50 pounds of roots may be fed to mature cattle in a properly balanced ration. Young cattle should be fed similarly on the basis of their live weight. In some cases a 1,000-pound steer will consume a ration of 100 pounds of roots, 10 pounds of dry roughage (principally straw), and 5 to 6 pounds of concentrates, about half grain and half oil-mill by-products, for a fattening period of three to four months.

For cows giving milk, roots are especially valuable. A small quantity of roots may often improve a ration containing liberal quantities of grain, legume hay, and silage. An old belief that roots produce milk with a higher water content than do dry rations has been disproved. White Belgian carrots may be fed to cows at 35 to 45 pounds per head. Mangels are less likely to taint milk than are rutabagas and turnips. Dairy cows may be fed 40 to 60 pounds of mangels daily. Rutabagas should be fed after milking or at noon to avoid tainting the milk.

Turnips are more watery than most roots and are fed principally to cattle and sheep. As they do not keep so well as some other root crops, they should be fed in the fall. Some dairymen feed the whole turnip plant because they believe that pound for pound the tops, which often constitute about 25 per cent of the total weight, are nearly equal to the roots in nutritive value.

ROOT CROPS FOR SHEEP

In general root crops are not an economical source of nutrients for sheep. In most cases silage is a more satisfactory source of succulence. While a sheep weighing about 100 pounds may consume as much as 15 pounds of roots, 2 to 3 pounds per head furnish plenty of succulence. Therefore, where roots are to be fed, a good fattening ration consists of approximately 2 to 3 pounds of roots, 1½ pounds of hay, and 1½ pounds of grain per 100 pounds of live weight. Experiments have shown that 1 pound of corn silage is equal to approximately 1½ pounds of roots in sheep feeding.

The favorite roots for sheep are rutabagas and mangels, although White Belgian carrots may be fed to ewes at 2 to 5 pounds per head, and turnips are also fed during the fall season. Feeding mangels to rams and wethers is believed by some persons to be dangerous because it may result in the formation of calculi in the bladder and kidneys, which may cause death. While efforts to prove this by experiment have not been successful, feeders are cautioned against the liberal use of mangels to male sheep. It is also thought by some that too free use of roots previous to lambing may increase the losses of young lambs.

ROOT CROPS FOR HORSES

Roots are used principally for horses as an aid to digestion. Their extensive use in the ration is not considered economical, as they are low in nutrients, being equivalent to only about one-fourth their weight in hay. Where roots are fed, other laxative feeds should be omitted, the roughage supply decreased, and the grain ration should contain feeds high in nutrients. Large quantities of roots are particularly objectionable for horses being worked or driven hard.

Carrots rank first among root crops as a horse feed. They are exceptionally good for colts, brood mares, stallions, idle work horses, and horses that are to be exhibited. Usually the quantity fed should not exceed 10 pounds per head daily. Chopping the roots is usually advisable. Care must be taken in feeding mangels to horses to avoid digestive disturbances. If the mangels are stored for a few weeks previous to feeding, the tendency to cause scouring is considerably reduced.

ROOT CROPS FOR HOGS

Roots have little value in the ration for hogs under ordinary farm conditions when good rations of concentrates are being fed.

Usually more satisfactory results have been obtained by feeding legume hay. According to the Michigan station, hogs will gather a crop of roots quite satisfactorily when they are given about one-third of a full ration of properly balanced concentrates.

While mangels, rutabagas, and carrots are considered practically equal in value for hogs, mangels are consumed with the greatest relish. Turnips are not a desirable hog feed.

In the United States and Canada wide variation in the replacement value of roots for part of the grain in swine rations has occurred in various tests. The following data give an idea of the range of values found at several stations:

Pounds of roots required to replace 100 pounds of grain in hog-feeding tests

Central Experiment Farm of Canada, Ottawa-----	786
Ohio Agricultural Experiment Station-----	642.5
Montana Agricultural Experiment Station-----	529
Utah Agricultural Experiment Station-----	455
Ontario Agricultural College-----	441.5
Average -----	570.8

There are no indications that beets, rutabagas, or turnips have an unfavorable effect on the quality of pork produced.

ROOT CROPS FOR POULTRY

Although mangels and carrots provide some succulence, they are not a satisfactory substitute for green feed for poultry. Rutabagas and turnips may be fed but are not so good as mangels or many other succulent feeds. As carrots are relatively rich in vitamin A they are considered the best roots for poultry.

COST OF PRODUCTION

The cost of producing root crops fluctuates from year to year and varies widely in different parts of the United States. Since much hand labor is required in producing the crop, the total cost is influenced largely by the prevailing wage and fertilizer prices. Except for harvesting and fertilizers it costs very little more to produce a good crop than a poor one; therefore, in those sections where big yields are usual, the cost of producing a ton of roots is relatively low. Rutabagas and turnips may usually be produced for 15 to 20 per cent less than mangels. Carrots are probably the most costly of the root crops commonly grown, mainly because of their smaller yields.

Because root crops compete with silage in furnishing succulence for winter feed, the relative cost of root crops and silage made from corn, vetch and oats, peas and oats, or other suitable crops should be considered. Where conditions are well suited to corn or other satisfactory silage crops there is no question that succulence in the form of silage may be produced more cheaply than succulence in the form of root crops, largely because silage production requires comparatively little hand labor. In some districts, however, with cool, moist climate especially favorable to root crops but not so well adapted to corn, the tonnage obtained from the root crops is so much greater than that of corn for silage that the production cost per ton is likely to be considerably less.

YIELDS

The yields of root crops vary with the climate, fertility of the soil, moisture supply, and other factors. As a rule, mangels produce a greater tonnage per acre than other root crops though sometimes, where the summers are short and cool and the moisture abundant, they are surpassed by rutabagas and turnips. Under favorable conditions, mangels, rutabagas, and turnips yield 20 to 40 tons per acre, while the usual tonnage obtained from carrots under similar conditions is about one-half this amount. In the northern Great Plains where the moisture supply is limited, mangels, rutabagas, and turnips yield on the average 5 to 10 tons per acre and carrots 2 to 4 tons per acre. In considering the value of root crops under dry-land conditions, the yields should be compared with those that may be obtained from other succulent crops, as corn and sunflowers, rather than with the yields obtained from roots under favorable moisture conditions. When this is done root crops show up more favorably, because they frequently give a greater tonnage than silage corn.

INSECT PESTS ¹

Mangels and carrots are seldom seriously damaged by insects, although occasionally cutworms destroy a stand to such an extent as to necessitate reseeding. Grasshoppers, aphids, flea beetles, cabbage worms, and root maggots are sometimes quite destructive. While the usual methods for controlling such insects as pests of garden crops are rather expensive, nevertheless the information that

¹ Contributed by the Bureau of Entomology and Plant Quarantine.

is available on the biology and control of these insects can often be adapted to their control as pests of root crops. Damage can usually be reduced by crop rotation, clean farming, and seeding at a time when insects are least likely to be prevalent in destructive numbers.

When severe injury is observed and information is desired, specimens of the insect causing the damage, together with a sample of the injured plant, should be sent either to the State experiment station or the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C.

DISEASES

Root crops in general are comparatively free from very destructive diseases. Mangels are sometimes attacked by dry rot, but this disease usually does not cause serious damage. A bacterial rot is sometimes quite destructive in turnips. Rutabagas and carrots seldom suffer seriously from disease attacks. When diseases appear, however, rotation of crops is the most practical means of control. Turnips are likely to decay rapidly in storage, but under suitable storage conditions decay losses are not usually serious with carrots, rutabagas, and mangels.

In the Pacific Northwest, the acreage of mangels and rutabagas is decreasing rapidly. The acreage of turnips is holding up fairly well. The acreage of carrots is increasing very rapidly, particularly from the standpoint of utility as human food and in a secondary way as consumed by livestock in utilization of the crops when the market may go bad and the culls in grading for cannery or table use. When varieties not adapted for human consumption are grown, the whole crop is fed to livestock. In addition to this, cannery refuse in the packing of carrots is practically all used for livestock feed, mostly by cattle and sheep rather than destroyed, as is the case with most other refuse from such plants.